OPTIMIZATION OF HYDROGEN PRODUCTION BY WATER ELECTROLYSIS

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A thesis submitted in fulfillment of the
requirements for the award of the degree of
Master of Science (Physics)

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SEPTEMBER 2014

I lovingly dedicate this thesis to my precious, the sweetest and dearly loved lady in my life, my mom, Che ku Mahani Binti Che Ku Daud and her strong spirit caring man, always my hero, Azni Bin Muda, special mate of mine MHAB who always support me, beloved siblings, family and friends,

Love,

Siti Radhiana Binti Azni

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ABSTRACT

Recently, hydrogen has been considered as a future energy carrier. Hydrogen is believed to be the most important long-term option for addressing the energy, environmental and economic concerns since it is a renewable and clean energy resource. The simplest and cheapest way to produce hydrogen is by electrolysis. However, the process is inefficient. Therefore the objective of this study is to enhance the hydrogen production by optimizing the electrolysis parameters as well as the laser parameters. In this study, fixed volume of distilled water was employed as medium and sodium chloride used as catalyst. Graphite rods were used as electrodes which were supplied by varying voltage. Molybdenum sheets with various surface areas were utilized as a sacrifice agent to protect the cathode. Meanwhile, ethanol solution was used to compensate oxidation by donating an amount of electron in the electrolyte was deployed as supplement. Hence the electrolyte parameters were optimized by varying the voltage, the sacrifice agents and electron donor. In addition, the hydrogen production was also enhanced by illuminating light into the electrolysis chamber. The light source was also optimized by varying the wavelength and the power of the light. In this study, the light source used comprised of diode-pumped solid state laser at various wavelength including, 485 nm, 532 nm, 635 nm, while nitrogen laser and conventional UV light source were at 337 nm and 403 nm respectively. The results obtained showed that the hydrogen increased with the voltage as well as the sacrifice agent area. The larger the voltage, the more the water splitting and the larger the area of sacrifice agent, the more protection on the cathode. Thus, more hydrogen production was encouraged. In contrast, the addition of the supplementary element ethanol was limited to 7 mL and above 7 mL, it resisted the hydrogen production. In the case of illumination light, green laser at 532 nm had shown a pronounced result. This was due to the light that is transparent to the water, thus contributing to more electric field into the electrolysis system. Furthermore, the higher the power of the green laser into the electrolysis chamber the more hydrogen production was realized. Thus, the effectiveness as well as the efficiency of the hydrogen production do relies on the optimizing parameters.

ABSTRAK

Mutakhir ini, hidrogen telah dipertimbangkan sebagai pembawa tenaga pada masa hadapan. Hidrogen dipercayai menjadi pilihan jangka panjang yang paling penting bagi menangani tenaga, keprihatinan terhadap alam sekitar dan juga ekonomi kerana ia adalah sumber tenaga yang boleh diperbaharui dan bersih. Cara termudah dan termurah untuk menghasilkan hidrogen adalah melalui elektrolisis. Walau bagaimanapun, kaedah ini masih tidak cekap. Oleh itu, objektif kajian ini adalah untuk meningkatkan penghasilan hidrogen dengan mengoptimumkan parameter elektrolisis serta parameter laser. Dalam kajian ini, isipadu air suling yang digunakan sebagai medium elektrolisis ditetapkan dan natrium klorida digunakan sebagai mangkin. Rod grafit digunakan sebagai elektrod yang dibekalkan dengan pelbagai voltan. Kepingan molibdenum dengan pelbagai luas permukaan digunakan sebagai agen korban untuk melindungi katod. Sementara itu, larutan etanol digunakan untuk mengimbangi pengoksidaan dengan mendermakan elektron dalam elektrolit. Oleh sebab itu, parameter elektrolit dioptimumkan dengan perubahan voltan, agen korban dan penderma elektron. Di samping itu, penghasilan hidrogen juga dapat ditingkatkan dengan memancarkan cahaya ke dalam kebuk elektrolisis. Sumber cahaya juga dioptimumkan melalui perubahan panjang gelombang dan kuasa cahaya. Dalam kajian ini, sumber cahaya yang digunakan terdiri daripada diod yang dipam oleh laser dalam keadaan pepejal dengan pelbagai panjang gelombang, termasuk, 485 nm, 532 nm, 635 nm, sementara panjang gelombang bagi laser nitrogen ialah pada 337 nm dan sumber cahaya UV konvensional pada 403 nm. Keputusan yang diperoleh menunjukkan bahawa hidrogen bertambah dengan pertambahan voltan serta luas permukaan agen korban. Semakin tinggi voltan, semakin banyak pemecahan air yang berlaku dan semakin besar kawasan agen korban, semakin banyak perlindungan terhadap katod. Oleh itu, menggalakkan lebih banyak penghasilan hidrogen. Sebaliknya, penambahan etanol sebagai unsur penambah hanya terbatas kepada 7 mL sahaja dan lebih daripada 7 mL, ia merintangi penghasilan hidrogen. Dalam hal pancaran cahaya, laser hijau pada 532 nm menunjukkan keputusan terbaik. Ini disebabkan, cahaya ini adalah lutsinar kepada air, dengan itu dapat menyumbangkan lebih banyak medan elektrik ke dalam sistem elektrolisis. Tambahan pula, semakin tinggi kuasa laser hijau dalam kebuk elektrolisis, semakin banyak penghasilan hidrogen yang dikenalpasti. Oleh itu, keberkesanan serta kecekapan penghasilan hidrogen amat bergantung kepada parameter yang dioptimumkan.